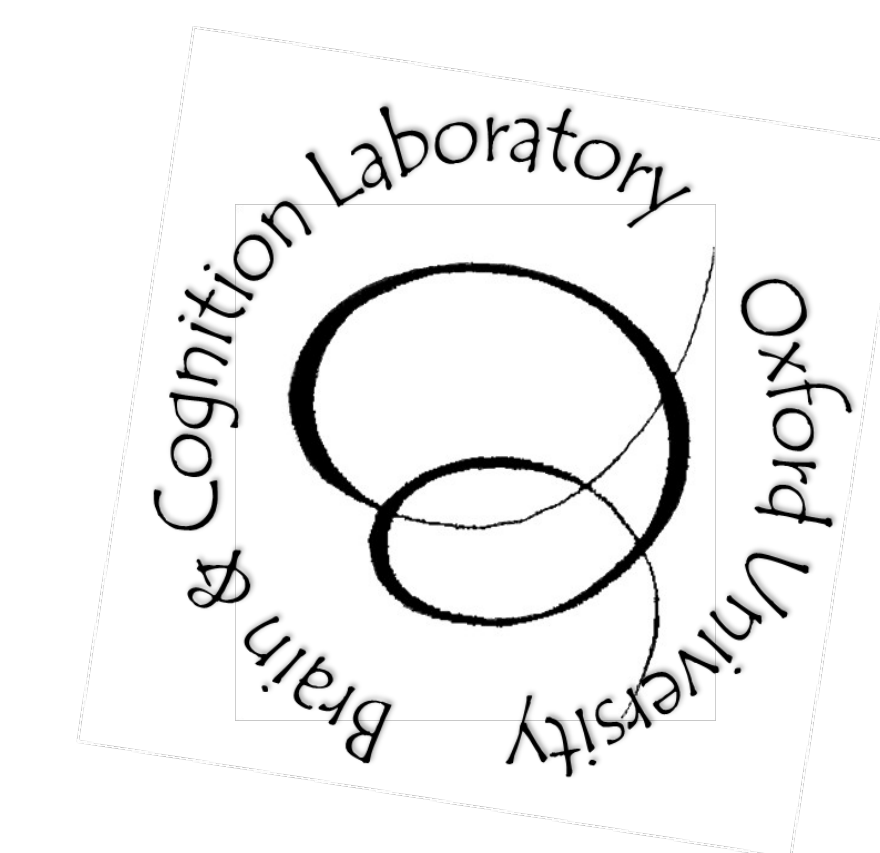


# The Effect of Retro-Cueing on an ERP Marker of VSTM Maintenance

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## Experimental Questions:

Performance based on VSTM can be improved flexibly by retro-cues that provide information about the location of potentially relevant items for guiding subsequent behaviour (Nobre, Griffin, & Rao, 2008). The mechanisms by which retro-cues operate are still under investigation. We tested whether spatial retro-cueing could modulate VSTM maintenance. We used the CDA as a marker of VSTM maintenance (Vogel & Machizawa, 2004; Vogel, McCollough, & Machizawa, 2005).

Specifically, we asked:

4. Does spatial retro-cueing improve performance on a VSTM search/retrieval task?
5. Is there a load-dependent CDA effect?
6. Is the CDA modulated by spatial retro-cueing?

## ERP Methods:

- The EEG was recorded continuously using Neuroscan 4.3 (40 channels, 1000 Hz rate, 0-200Hz filter)
- Re-referenced offline to the averaged mastoids and low-pass filtered (40 Hz)
- ERPs around memory array (-200 to 1800 ms)
- Epochs containing blinks, saccades or drifts excluded

## Findings & Conclusions:

Analyses revealed a number of both surprising and expected results.

3. Both accuracy and reaction times were facilitated by retro-cues.
4. The CDA was significantly affected by the load of remembered items.
5. CDA diminished upon presentation of a retro-cue, regardless of whether it was a neutral or spatial cue.

## References:

- Nobre, A. C., Griffin, I. C., & Rao, A. (2008). Spatial attention can bias search in visual short-term memory. *Frontiers in Human Neuroscience*, 1(4), 1-9.
- Vogel, E. K., & Machizawa, M. G. (2004). Neural activity predicts individual differences in visual working memory capacity. *Nature*, 428, 748-751.
- Vogel, E. K., McCollough, A. W., & Machizawa, M. G. (2005). Neural measures reveal individual differences in controlling access to working memory. *Nature*, 438, 500-503.

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## Behavioural Task:

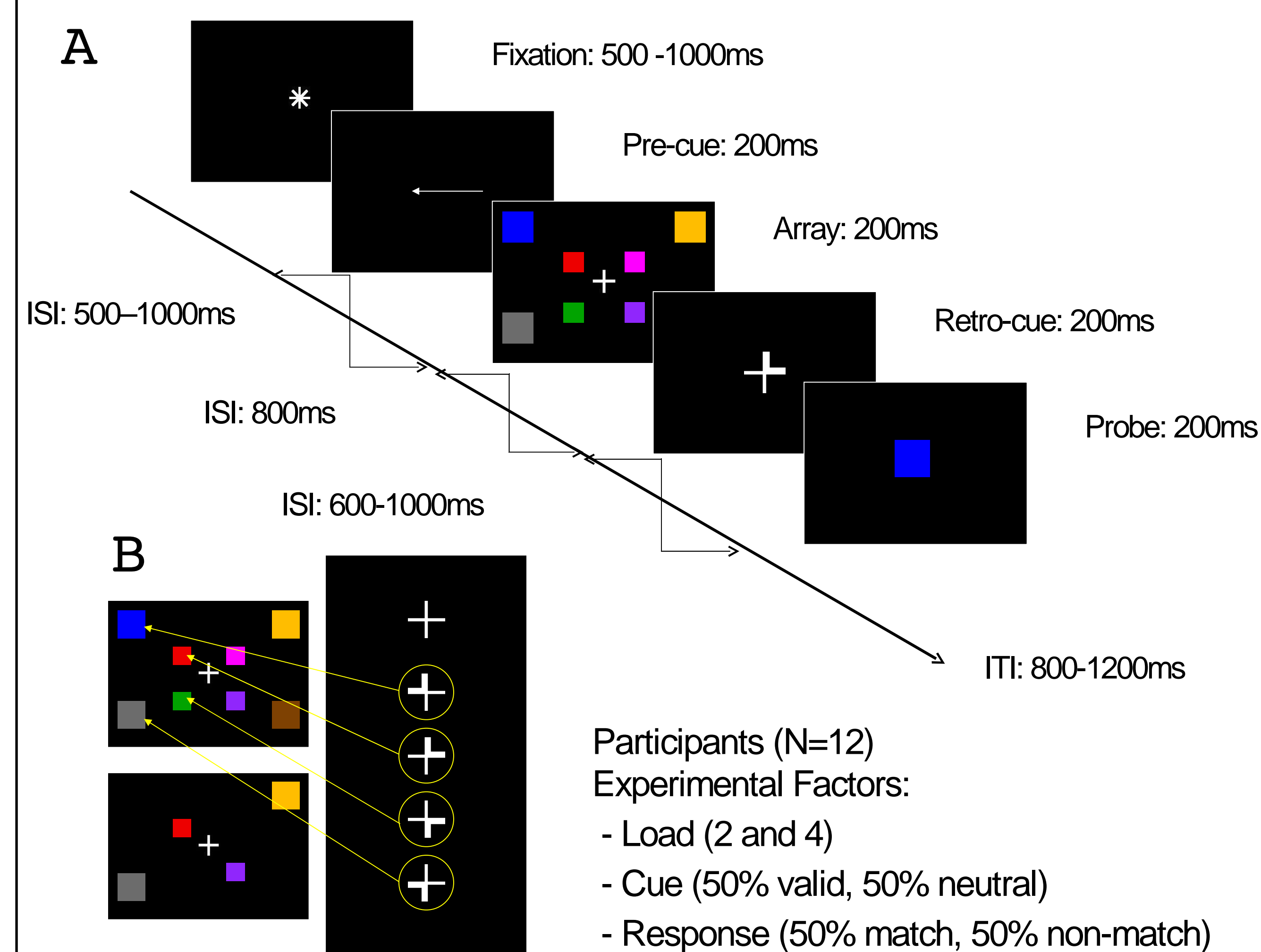


Figure 1: (A) The fixation cross was followed by a pre-cue directing attention to one side of a memory array (2 or 4 items on each side). After a delay, a retro-cue further directed attention to the relevant items. Participants responded to whether a probe was present/absent.

(B) Meaning of the five possible cue types (neutral and four from the cued side of the display: upper left, upper right, lower left, lower right). The left panel provides an example of the two load conditions.

## Behavioural Results:

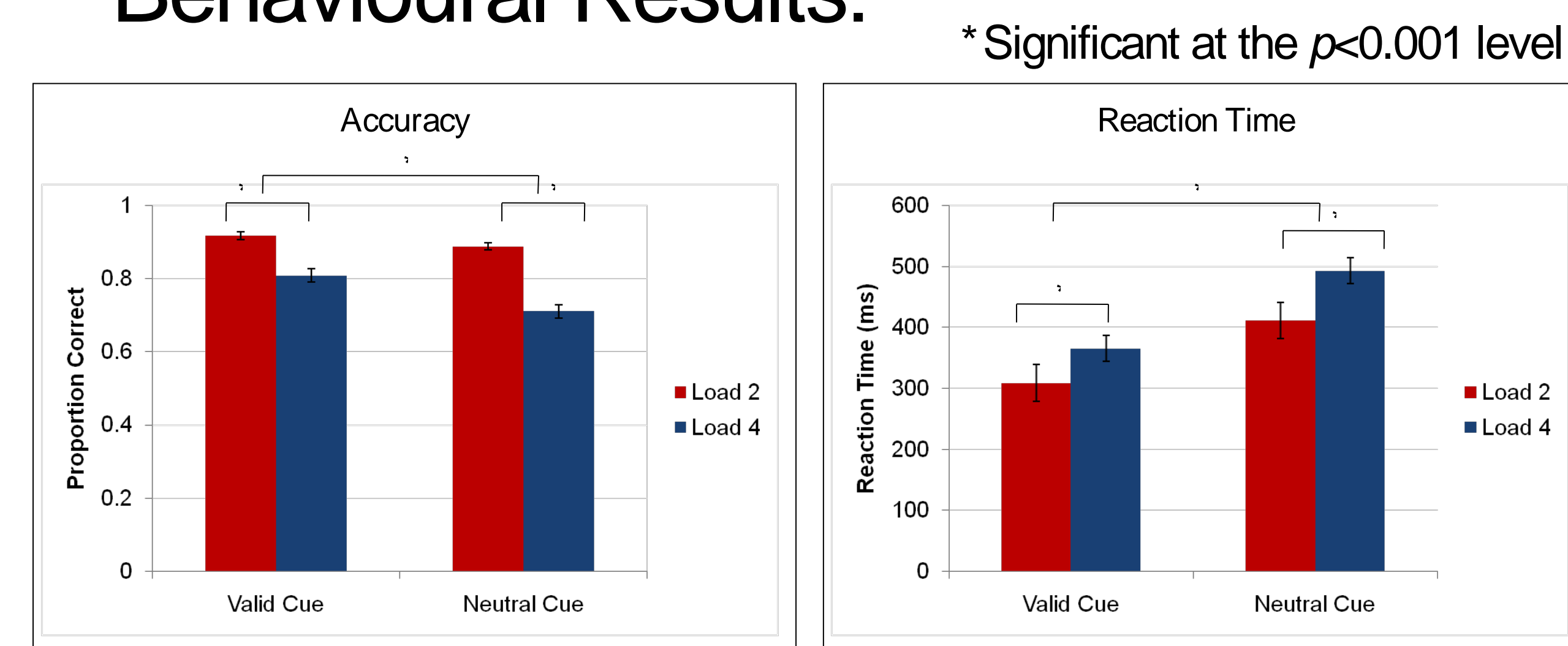


Figure 2: Accuracy and Reaction Time (RT) data in terms of the load of items in the memory array and the validity of the retro-cue.

**Validity:** Accuracy ( $F(1,11)=36.43, p<0.001$ ), RT ( $F(1,11)=115.90, p<0.001$ ).

**Load:** Accuracy ( $F(1,11)=115.63, p<0.001$ ), RT ( $F(1,11)=33.06, p<0.001$ ).

**Interaction:** Accuracy ( $F(1,11)=15.52, p=0.002$ ), RT ( $F(1,11)=3.51, p=0.09$ ).

**$d'$ :** Cued ( $d' = 1.60$ ) compared to neutral ( $d' = 1.22$ ) ( $t(11)=6.41, p<0.001$ ).

## ERP Results:

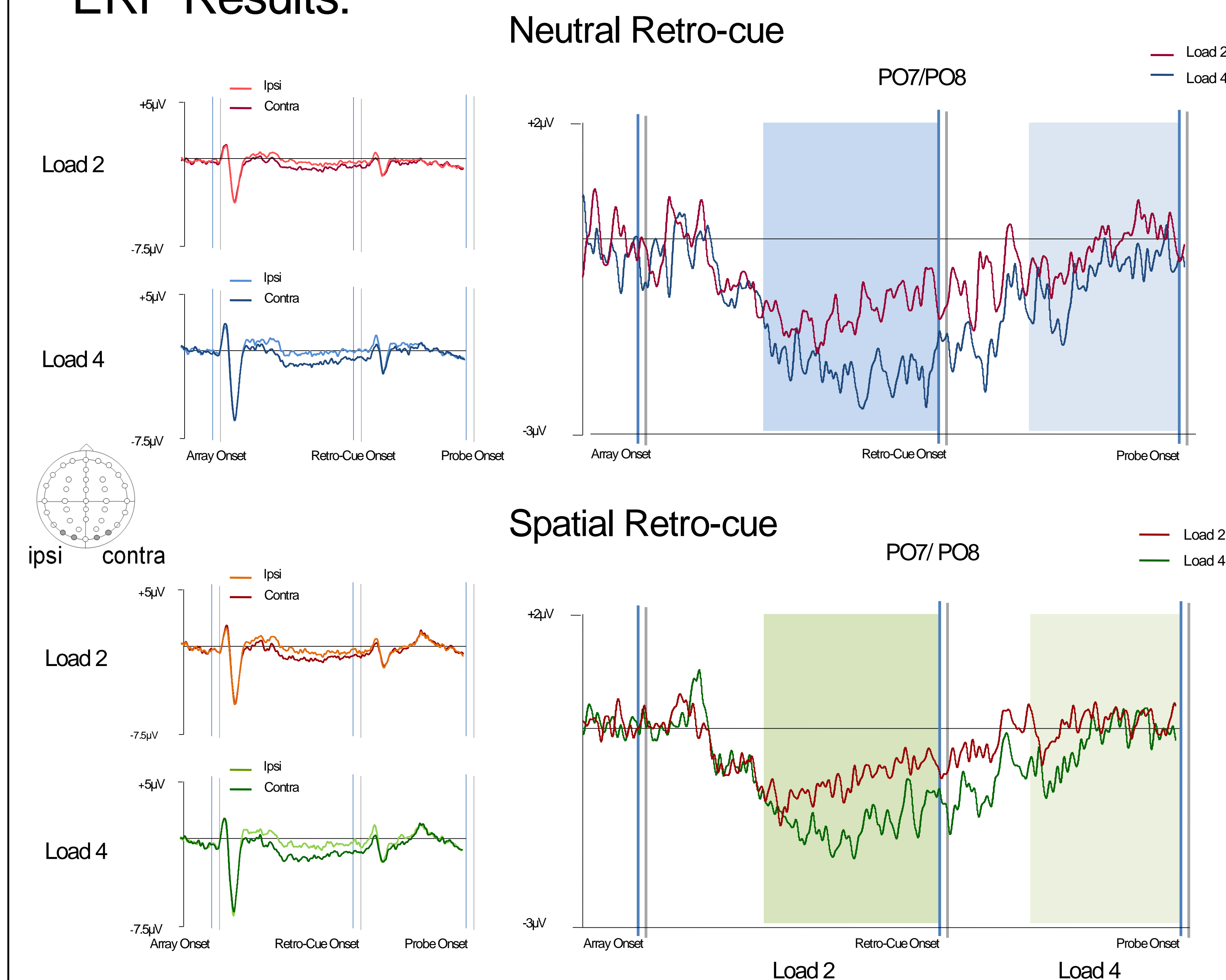


Figure 3: The averaged ERP waveforms time-locked to the presentation of the memory array in the spatially and neutrally retro-cued conditions over posterior contralateral and ipsilateral electrodes (PO7/8) (positive voltage is plotted up). The difference between contralateral and ipsilateral waveforms (CDA) is plotted on the right. Shading indicates the two time periods of interest for the analysis: 400-1000ms after the memory array and 300-800ms after the retro-cue.

A repeated-measures ANOVA (over P7/P8, PO7/PO8, P3/P4 and PO3/PO4) tested the effects of cue (spatial, neutral), load (2, 4) and time period (pre-cue, post-cue). The CDA was significantly modulated by load ( $F(1,11)=5.28, p=0.042$ ) and by time period ( $F(1,11)=31.997, p<0.001$ ). Critically, there was a significant interaction between time and load ( $F(1,11)=6.74, p=0.025$ ) suggesting that the CDA diminished with the onset of a cue ( $F(1,11)=6.28, p=0.042$ ). This was, however, independent of cue validity ( $F(1,11)=0.04, p=0.85$ ).

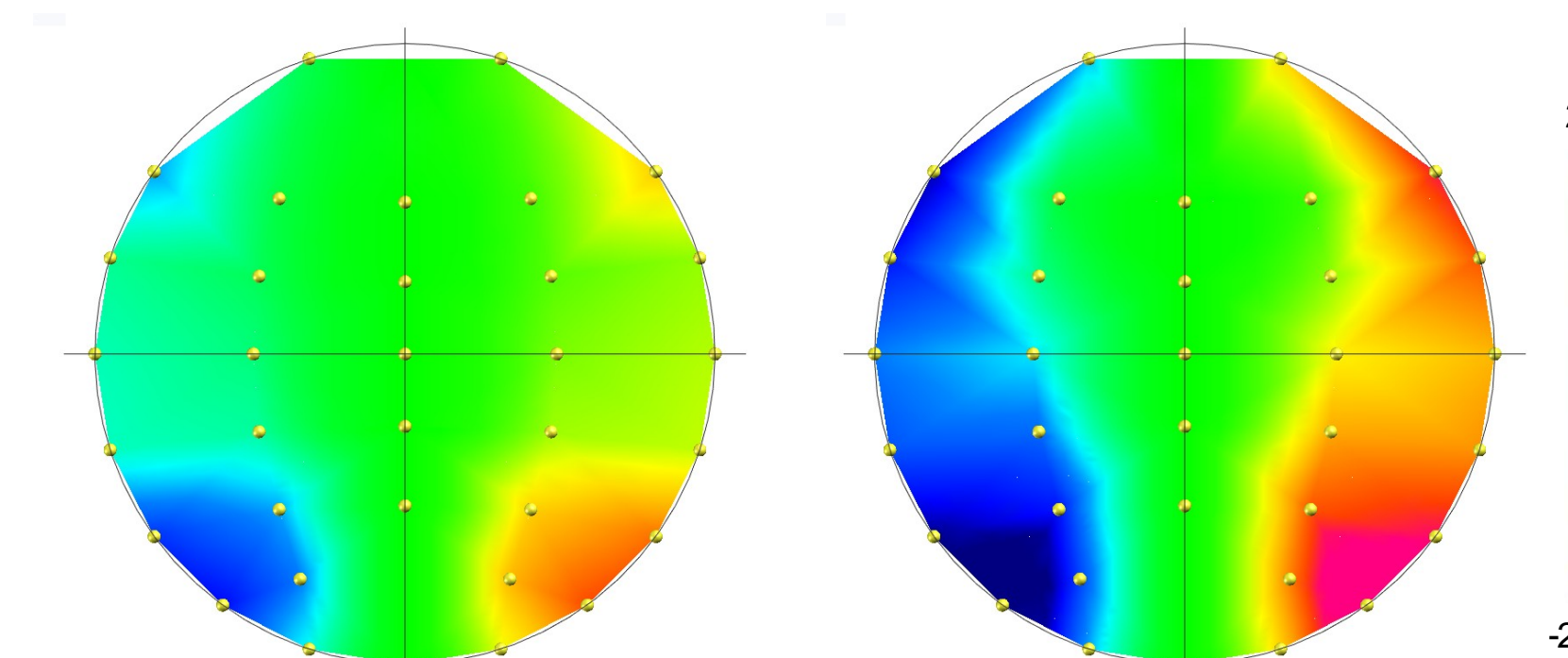


Figure 4: Two-dimensional scalp topographies averaged across cue type for 400-1200ms.



Figure 5: A frontal CDA was also observed, shown for the neutral and cued conditions (averaged over F7/8, FT7/8, FP1/2).